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Design and fabrication of electric 4- wheeler

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Abstract: *This paper is written in consideration with Brushless DC motor (3.5 kW) and Lithium-ion battery (78 Amphr). Here the motor is considered as the driving element for propulsion and the battery pack for the energy storage for the model. Pollution by IC engine vehicles is one of the primary reason to ruining the air quality throughout India, leading to increased disease rate and vicious side effects, in turn to decreasing economic productivity. This problem has turned the industry to plan for green transportation means. There have been government and private spokespersons running by various identities to address the issue of IC vehicle pollution through deployment of electric vehicles seminar and interactive courses. Due to high costs and low performance parameters, attempts for commercialization of these vehicles is not actually successful. This paper presents the challenges faced and lessons learned during the designing phase of electric vehicles with favorable life cycle costs. This paper explains the concept of the study on the different types of motor and battery used for the designing an electric vehicle according to personalized needs.*

Keywords - *four-wheeler, electric vehicle, cost, auxiliary solar charging, Li-ion battery pack.*

I. INTRODUCTION

In this paper, we will discuss about the usage of Li - ion Battery to power up the vehicle. In order to achieve the required voltage, the Li - ion Battery may be connected either in parallel or series, but its costlier. Thus, to make it cost effective, power converters and batteries are been used. The electrical charge is consolidated from the Li - ion Battery and directed to the output terminals to produce low voltage (Direct Current). The BMS direct this power acquired to the batteries. The complete hardware integration of the system is tested to meet up the application's requirement. The long-term objective of this paper is to design, fabricate and assemble a fully functioning vehicle powered by solar energy. The goal for this year's team is to develop a electric vehicle and to purchase exact components within our budgetary constraints.

This will consist of the following:

i. Frame:- Frame design, Analysis and Fabrication
ii. Power train:- Power train design
iii. Motor research:- Selection and Purchase
iv. Parametric analysis of required power:- Control research, Design and Purchase.
v. Battery & BMS:- Research, Selection and Purchase.

II. METHODOLOGY

2.1 Working of the System

When the throttle is energized which means the potentiometer in the throttle gets input and provides the signal to the controller as in how much power it is supposed to deliver. There are two potentiometers in the throttle if one fails the other keeps operating. The controller computes the value of the accelerator from the potentiometers and then delivers power accordingly, from the batteries to the motor. The motor asses the power from the speed controller for transmitting that power into wheels. If accelerator is pressured then the controller

delivers the battery voltage to the motor with respect to its value after the input from rider. If the accelerator is depressurized, the controller deliver voltage to the motor with respect to the input.

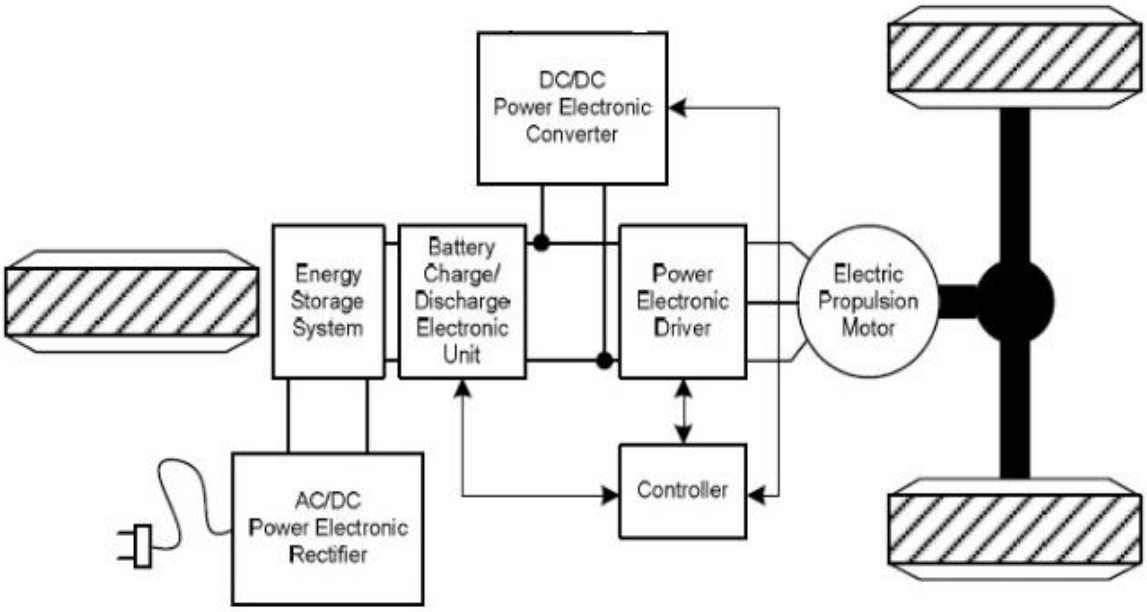

Figure 1: Block Diagram

2.2 CAD Designing

The chassis is basically a skeleton or a base of an automobile. CAD design is the process of developing the virtual model and the ergonomics, of the vehicle which is to be designed. In this paper it is primarily related with developing the visual appearance of the vehicle one wishes to design. The theoretical value needs to match with the ergonomic features and utility features as well. this type of designing is basically making a virtual 3 D image of the designers model.

The Chassis consists of following:

1. Body shell which is the skeleton of the vehicle.
2. Engine that concludes the power train unit of the vehicle.
3. Transmission system it transfers the drive from the engine to the wheels, via clutch, gearbox, and differential.
4. Suspension system which used to connect the wheels to the chassis frame.
5. Steering system
6. Brakes
7. Electrical equipment
8. Interior: dashboard, door panels, headliner, seats, etc.

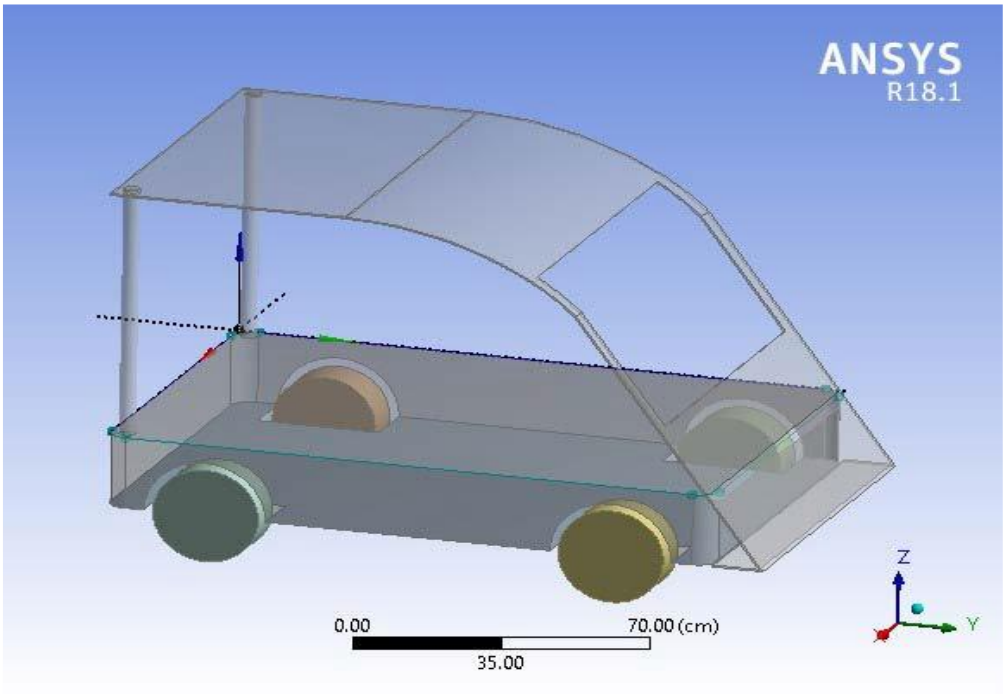

Figure 2: System model design

2.3 Mathematical Formula for Designing

- Mechanical Calculation

1. Rolling Resistance Force = F_r

$F_r = Cw = C*m*a_g$

C - Coefficient of Rolling resistance of road

2. Acceleration Force = F_{acc}

   F_{Acc} = GVM * acceleration*sinα

   α = Angle of inclination with respect to the horizontal [Degrees]

3. Aerodynamic Force = Drag Force = F_d

   $F_d = C_{d12*\delta*A*V^2}$

   C_d = Drag coefficient

   δ = Density of Medium

   v = Velocity of object in m/sec

   A = Frontal area of the object

4. F_t = Summation of all forces

   $F_t = F_r + F_d + F_{ACC}$

- Motor Calculation

5. P_{req} = Power required

   $P_{req} = F_t * \frac{V}{\eta m}$

6. Wheel rpm = Ω_w

   $\Omega_w = \frac{V}{C}$

   c = Circumference of the tyre

7. Required Motor rpm of system = Ω_M

   Ω_M = Gear ratio * Wheel rpm (Ω_w)

8. Required Torque of system = $\dot{T}$

   $\dot{T} = r \times Ft$

   r = Radial distance

- Battery Calculation

9. Volume of cell = Vcc = $\frac{\Pi*Batterycelldiameter*Batterycelllength}{4}$
10. Battery Cell energy = Battery cell capacity * Battery cell voltage
11. Battery cell energy density = $\frac{\text{Battery cell energy}}{\text{Battery cell mass}}$
12. Battery pack total energy = $\frac{\text{Motor voltage} * \text{Ampere drawn} * \text{Distance}}{\text{speed (kmph)}}$
13. Energy content of string = Cells in series * Energy of battery cell
14. No. of string of battery pack = $\frac{\text{Battery pack Total energy}}{\text{Energy content of each string}}$
15. Peak current = crate * Battery cell capacity
16. Battery pack peak current = Peak current * No. of strings of battery
17. Battery pack peak power = Battery pack peak current * Battery pack voltage
18. String continuous current = Crate * Battery cell capacity
19. Battery pack continuous current = String continuous current * No. of strings
20. Battery Pack continuous power = Battery pack continuous current * Battery pack voltage

III. FIGURES AND TABLES

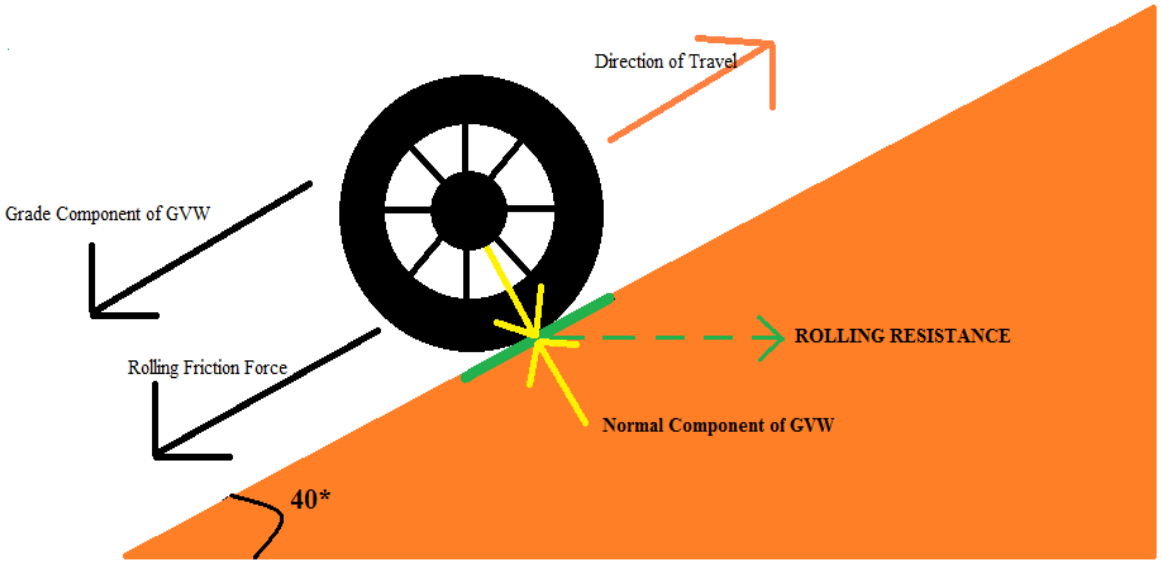

Figure 3: - Force on tyre from all direction in an inclined surface

Table 1: - Values of rolling resistance on different surfaces

Coefficient of rolling resistance (C_{rr})	SURFACE
0.001 - 0.0025	Steel Wheels on Steel Trails
0.0015 - 0.0025	Bicycle tyres on Concrete
0.006 - 0.01	Truck tyre on Asphalt
0.01 - 0.015	Car tyre on Concrete
0.03	Car tyre on Tar or Asphalt
0.2 -0.4	Car tyre on Loose sand
0.004	Bicycle tyres on Asphalt

Table 2: Comparison of different types of Motor on the basis of their mechanical and performance specification

MOTOR	PMDC	AC INDUCTION	BLDC
VOLTAGE	DC	AC	AC,DC(CONTROL)
SPEED(RPM)	1000-5000	1350-3400	1000-5000
HP	MEDIUM	LOW-MEDIUM	HIGH
EFFICIENCY	60-70%	40-80%	65-80%
LIFE	MEDIUM	VERY HIGH	VERY HIGH
MAINTENACE	MEDIUM	VERY LOW	VERY LOW
NOISE	MEDIUM	QUIET	VERY QUIET
SPEED REGULATION	FAIR	GOOD	EXCELLENT
STARTING TORQUE	VERY HIGH	LOW-MEDIUM	VERY HIGH

Table 3: - Comparison of different types of Battery on the basis of their chemical and performance specification

BATTERY SPECIFICATION AND TYPES	**LEAD ACID**	**NiCad**	**NiMH**	**Li-ion**
Energy/weight (Wh/kg)	30-40	40-60	30-80	160
Energy/size (Wh/liter)	60-75	50-150	140-300	1400
Charge/discharge Efficiency (%)	70-92	70-90	66	99.9
Self-discharge rate (at 20 C) (%)/month	3-20	10	30	5-10
Cycle durability (cycles)	500-800	2000	500-1000	1200
Life (years)	2-8	3-10	2-5	2-3
Nominal cell voltage (V)	2	1.2	1.2	4
Operating temperature(C)	-40 to 60	-40 to 60	-20 to 50	-20 to 50

IV. CONCLUSION

From this paper reader gets a clear view of a method for designing his personal Electric Vehicle. It gives broader perspective about confusion regarding various time consuming and complex methodology. This paper consist of various type of electric vehicle and their requirements for example and better understanding. Reader get a definite vision about designing any choice of vehicle as an beginner.The analysis presented in this paper was done with primary and secondary research, including previous research paper as well as a survey of nearly 20 webinars on designing a vehicle. To this qualitative and quantitative data, was applied in various of retrofitted and self manufactured vehicles. The thinking of the society towards designing EVs is still unpleasant as a major section of it is still unaware of various other technologies which are also used in automobiles for propulsion.

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